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# RADIOACTIVITY FROM URANIUM MINING AND ITS RELATIONSHIP TO FISH

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## RADIOACTIVITY FROM URANIUM MINING AND ITS RELATIONSHIP TO FISH

Every living thing on earth is exposed to natural radiation. This radiation comes from cosmic rays that enter the earth's atmosphere from outer space and from radionuclides in the earth's crust. Fish, no matter where they exist are exposed to a certain amount of this natural background radiation. Some locations, however, have higher background radiation than average because of the presence of uranium or thorium ore bodies. As a result, fish from lakes and streams in uranium-rich areas are exposed to more natural background radiation than fish from areas with no uranium ore bodies.

Radiation exposure in fish can also be increased by human activity. For example, uranium mining and milling, nuclear power plants and fallout from nuclear weapons tests can all increase the amount of radioactivity in lakes or streams, causing increased exposure to fish.

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### WHAT IS RADIOACTIVITY?

Everthing on earth is made up of natural building blocks called atoms. Atoms have a central dense core, the "nucleus", that contains two kinds of particles called protons and neutrons (except hydrogen which has only one proton). Protons have a positive electrical charge; neutons have no electrical charge. A cloud of negatively charged particles called electrons surrounds the nucleus.

The number of protons in each type of atom is unique; however, the number of neutrons in each type of atom can vary. In stable atoms, the forces holding the nucleus together (provided by the neutrons) balance

the forces forcing it apart (caused by the protons repelling each other). In unstable atoms, called radionuclides, these forces no longer balance and the atom seeks a more stable state by changing the number of neutrons and protons through a process called radioactive decay. This decay continues until the element becomes stable. "Radioactivity" is a general word that refers to all of the different types of particles and energy produced during radioactive decay.

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Nuclear Fission

In elements with a large imbalance of neutrons and protons another form of nuclear instability can result: the nucleus actually breaks into two. The division, called nuclear fission, releases radiation in the form of several neutrons and a large amount of energy. It also produces new radionuclides which undergo radioactive decay and give off more radiation. Fission can occur naturally, but at extremely slow rates. It can also be produced in nuclear power plants and by the explosion of nuclear weapons. Man-made fission produces "artificial" radionuclides that do not occur naturally, for example, $^{137}$cesium and $^{90}$strontium.

How Living Tissue is Damaged

Nuclear decay involves the ejection of alpha particles (two protons and two neutrons) or beta particles (electrons) or gamma rays, a form of very penetrating radiation similar to X-rays. The release of energy from the nucleus ejects alpha and beta particles at very high speed.

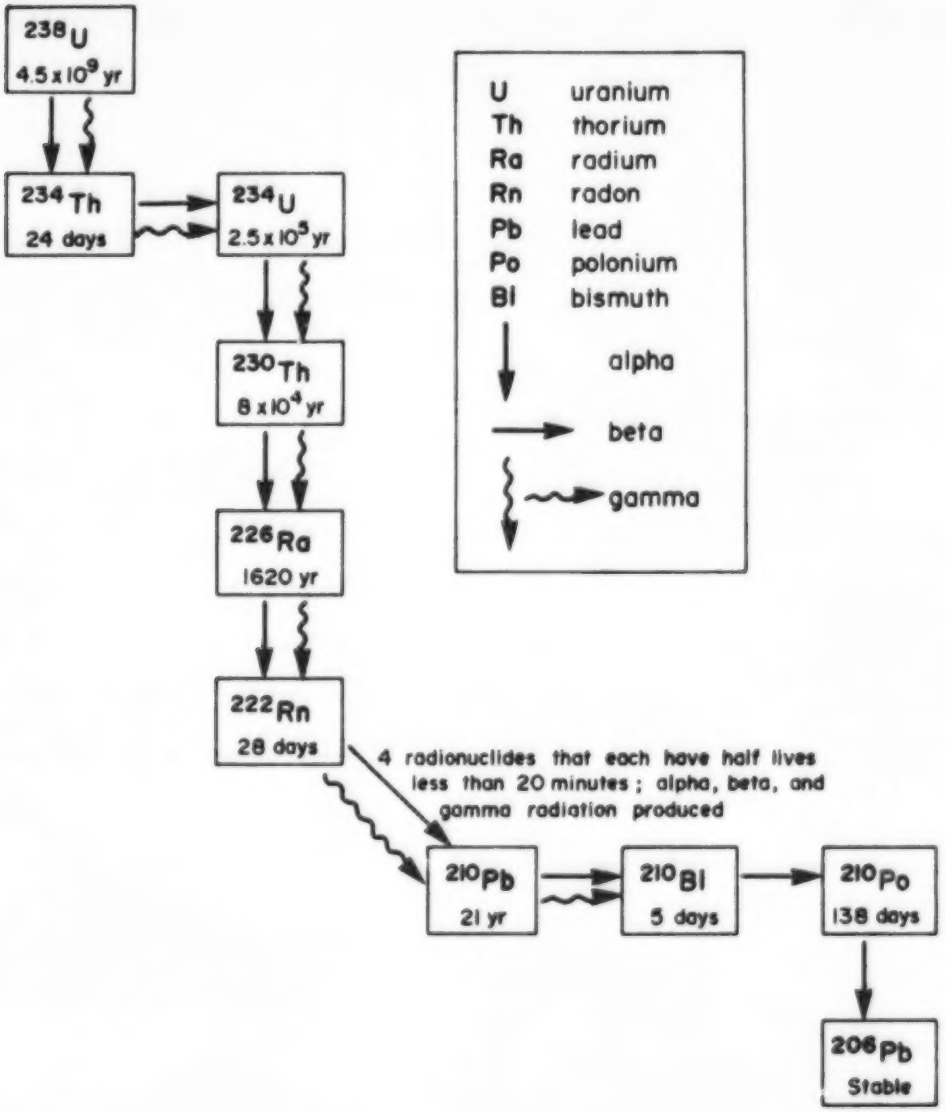
Alpha, beta and gamma radiations can all disturb the electron clouds of other atoms that they encounter, causing the formation of electrically charged atoms (called ions). They can also break the chemical bonds that join atoms. Radiation damages living tissues by ionizing the atoms or breaking chemical bonds between the atoms in the body's cells. For example, changes in the atoms making up the genetic material may occur; these changes increase the risk of hereditary disease or abnormal development of offspring. Changes in the genetic material or in the parts of the cell that control cell division can increase the risk of cancer.

----------End of Shaded Section----------

Uranium Mining and Fish

This brochure concentrates on uranium and the "uranium series" decay chain of elements. Although uranium is a naturally occurring radionuclide, exposure to radiation from the uranium series is enhanced by uranium mining and milling. During uranium mining the ore is brought to the surface, where it is crushed and chemically treated. This produces a large amount of waste material, called tailings, which contains the radionuclides in the uranium decay chain (the "daughters" of uranium). These daughter radionuclides are the main source of radiation from uranium mine tailings.

********** uranium chain diagram **********




"The uranium decay chain. The half-life of each radionuclide is noted underneath each radionuclide symbol. Most of the radiation produced is alpha and beta, although a small amount of gamma radiation is also produced by several of the radionuclides."

Radionuclide Half-Lives

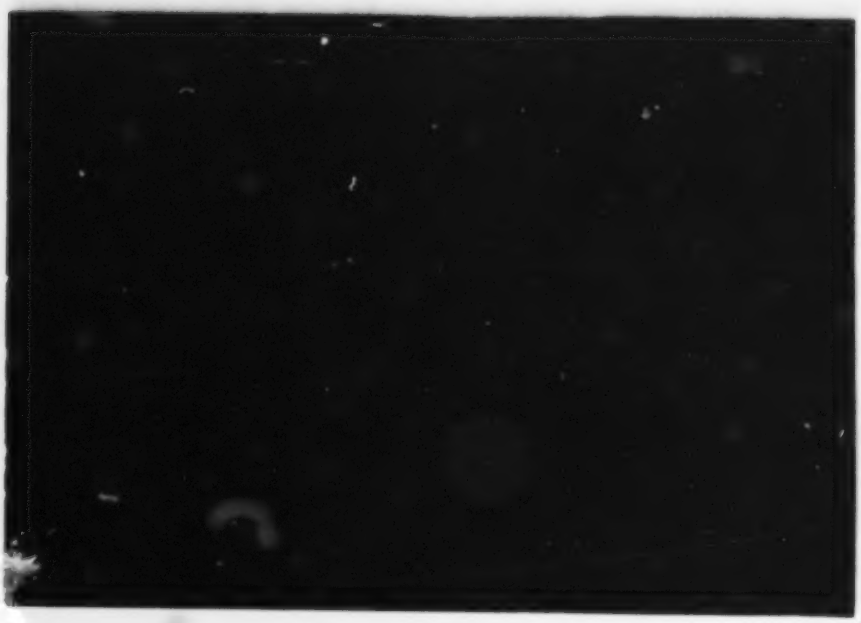
Each daughter radionuclide has its own chemical and physical properties. For example, some uranium daughters dissolve in water more easily than others. One, radon, is a gas. Also, each daughter radionuclide has its own "half-life". Half-life is the time it takes for one-half of a given amount of a radionuclide to decay. For example, it takes 4.5 billion years for one-half of the $^{238}$uranium in an ore-body to decay. Half of the $^{210}$lead in that ore-body would decay in 21 years.

Half-lives are important because they affect how much radiation is produced by a radionuclide in a given time period. For example, $^{210}$lead gives off more radiation in 1 day than uranium does. This means that a fish (or a person) exposed to $^{210}$lead for 1 day receives more radiation than a fish exposed to $^{238}$uranium for 1 day. The important factor is the rate of decay. It's like the difference between a thunderstorm which dumps 3 inches of rain in 1 hour and a gentle rain which lasts for 2 days.

********** selected photos of uranium mines and tailings here **********

The Eldorado Nuclear uranium mill, near Uranium City. It operated until 1982.

The Stanrock tailings area, near Elliot Lake, Ontario. These tailings were produced by a mine that ceased operations in 1970. The tailings runoff is now treated before it flows into a chain of lakes downstream.



The Rabbit Lake open pit uranium mine, Wollaston Lake, Saskatchewan, which is now mined out and receiving tailings from a new mine. The tailings pond is in the background at the top of the photo. Discharge from the pond entered Wollaston Lake via a small stream.

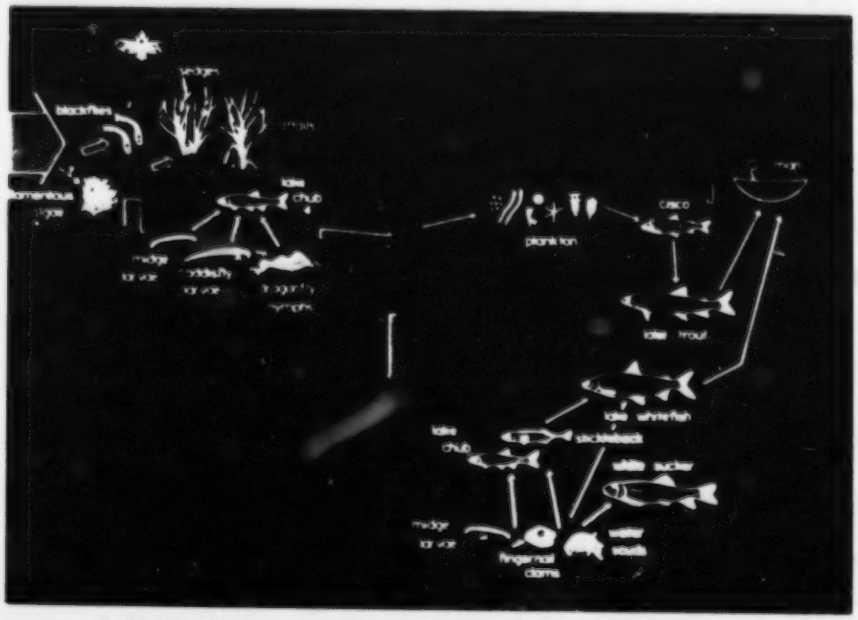
Aerial view of Fookes Lake (foreground), used for tailings settling at former uranium mines near Uranium City, Saskatchewan. This lake drains through a decommissioned settling pond and two smaller lakes to Beaverlodge Lake (centre left).

The Gunnar uranium mine on the north shore of Lake Athabasca, northern Saskatchewan, abandoned in 1964. The flooded open-pit is in the centre of the photograph; the head-frame for underground workings is to the right.

The Panel uranium mine, Quirke Lake, Ontario. This mine is currently operating. Its tailings are treated and discharged to a series of settling ponds. From there, water is allowed to be discharged into Quirke Lake after meeting regulatory limits.

food chain. Unlike other substances such as mercury the amount of radionuclides present at each successive step in a food chain usually decreases. Thus, predatory fish such as pike will be exposed to less radiation via their food than insects living in the bottom mud.

********** food chain diagram here **********




A diagram of food chains in Beaverlodge Lake, northern Saskatchewan, near Uranium City. Arrows correspond to the path of the radionuclides. The width of arrows corresponds to the relative amount of radionuclide travelling along that path.

Studies of fish near older Saskatchewan uranium mines (those that operated in the 1950's and 1960's) have shown that they have significantly higher radionuclide levels than fish living where no mines exist. Fish near newer mines (those that started operating in the late 1970's-early 1980's) have not shown any increase in radionuclide content.

There have not been as many studies on fish near Ontario uranium

## HOW DOES RADIOACTIVITY GET INTO FISH?

Radionuclides enter water from the surrounding land via runoff or percolation through the soil, from the air via release and migration of radon gas, rain, snow, or dust and from other water bodies. For example, uranium tailings placed in a depression near a lake can release radionuclides to that lake by seepage through the ground, by overflow, via radon gas migration or, if the tailings dry up, by dust blowing off the tailings. At older mine sites, tailings were frequently added directly to lakes, forming exposed deltas and sometimes completely filling the lakes. At all the mines operating now, regulations require that the tailings be isolated and protected from all forms of erosion. The water released from these tailings areas must have radionuclide levels that are below limits set by the regulations.

Once in the water, radionuclides either remain dissolved or settle out to the bottom and attach to sediment material. Fish are therefore exposed to radioactivity both from the water and the bottom sediments. In addition to external radiation exposure, fish can take radionuclides into their bodies through their gills or through the food they eat. They can also accidentally ingest radionuclides in sediments during their feeding.

### Radionuclides in the Food Chain

The radionuclides in fish may have passed through several other animals and plants first. For example, radionuclides in the bottom mud may first be eaten by worms, which are then eaten by insects which are then eaten by small fish which are then eaten by larger fish such as pike. This step-by-step progression through several animals is called a

mines as there have been near Saskatchewan mines. In the late 1960's, a few measurements of radionuclides in fish food organisms living in lakes near uranium mines showed definite radionuclide increases downstream of the mines. Levels were still elevated when checked again in 1984. A few measurements of fish in this area in 1984 showed radionuclide levels in 2 of the lakes were similar to those found in Beaverlodge Lake, Saskatchewan.

## DOES THE ADDITIONAL RADIATION NEAR URANIUM MINES HARM FISH?

Most of what we know about the effects of radiation on fish comes from studies using high radiation doses. Based on these studies, it has been concluded that radiation doses in natural lakes and streams near uranium mines are at least 100 times lower than those which would affect fish. However, while the risk is probably small, we are uncertain about the effects of a long period of exposure to low doses of radiation.

### More Knowledge is Needed

First, we need to know the difference between the effects of gamma radiation and alpha or beta radiation. Almost all of our knowledge about radiation effects in fish is from studies of gamma radiation. Most radiation in fish near uranium mines is alpha and beta. Alpha and beta particles cannot penetrate tissues as far as gamma rays can; however, once eaten or absorbed through skin or gills, they do more damage along the shorter distances that they travel. Therefore, exposure to low dose alpha and beta radiation may cause damage to fish populations over the long term.

Second, if there are long-term effects of low dose radiation near

uranium mines, they should not be large-scale and dramatic. Rather, there could be slow, subtle changes in genetic make-up, causing, for example, an increase in susceptibility to disease, or a decrease in the ability to produce young. These changes would be extremely difficult to detect. Another problem is that there are many other factors in the natural world that affect fish populations. It would be like trying to pick out a melody in a symphony recording when only the violins are following the tune.

The problems with interpretation of field studies on the effects of radiation are shown by the following example. Blood is very sensitive to radiation. Therefore, a study of blood characteristics in fish near a uranium mine was done. The study results showed that fish near the mine had different blood characteristics than fish from two other lakes. However, there are many natural causes of changes in blood. Thus, this type of study cannot prove that radiation produces the observed differences.

A better understanding of the long-term effects of exposure to low-level radiation depends on further research. Laboratory studies where factors can be controlled are needed. In addition, field experiments combining some of the advantages of both laboratory and field research are required.

***** photo of fish blood sampling or general fish sampling here *******

Taking blood samples from a fish, Fredette Lake, near Uranium City, northern Saskatchewan.

(Alternative photo to Fish Blood Sampling)
Collecting data on fish sampled from Beaverlodge Lake.

Risk To Fish Appears Small

All we can say at this time is that we are reasonably sure that the risk to fish from radiation near uranium mines is very small. We cannot say that there is definitely no risk of any damage either now or in the future.

SHOULD PEOPLE EAT FISH FROM AREAS WITH ELEVATED LEVELS OF RADIONUCLIDES? We don't see why not.

********** photo of person fishing here **********

Lake trout captured in the Beaverlodge area, northern Saskatchewan.

So far, all studies of radiation dose to people living near uranium mining areas, nuclear power plant areas (that have not had an accident), or areas where fallout radionuclides have been measured, show that the increase in risk from regularly eating these fish is extremely small. For example, the dose to people in a uranium mining area from eating one serving of fish per week for a year was estimated to be 2% of the allowable dose to the general public. Another calculation showed that a person would have to eat 2,285 servings of fish from the mine area in one year (more than six servings per day) in order to reach the annual limit of intake for the most dangerous radionuclide.

Of course, fish are not the only source of radiation to people. All radiation sources must be considered when assessing total risk, but tourists and northern Saskatchewan residents should not hesitate to eat their catch.